Three Metabolic Pathways

(Text Pg 82 – 86)

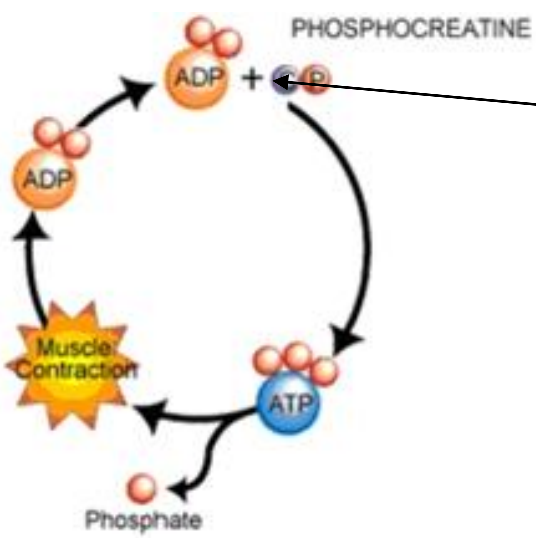
1. ATP – PC *(Anaerobic Alactic)*

2. Glycolysis *(Anaerobic Lactic)*

3. Aerobic Oxidative *(Aerobic Alactic)*
- Oxidative Phosphorylation
- CELLULAR RESPIRATION (Glycolysis → Krebs Cycle → Electron Transport Chain)

1. The High Energy Phosphate System

When? Initial onset of activity (quick bursts)
Where? Cytoplasm
Peek Production Lasts? 10 – 15 seconds
Substrate? Phosphocreatine
Process? One reaction regulated by enzymes (Creatine Kinase)
- PC + ADP » ATP + Creatine *(See diagram below)*



Creatine Kinase (ENZYME) is responsible for the breakdown of CREATINE PHOSPHATE.

Limitations:
- Muscle only has small amounts of PC available
- Only one ATP per reaction

Benefits: Very fast rate of production of ATP
Replenishment: during recovery phase (2 – 5 minutes) requires ATP (P_i + creatine + energy ↔ ATP)
Where in sports? Sprints, throws, jumps, power moves or explosive power

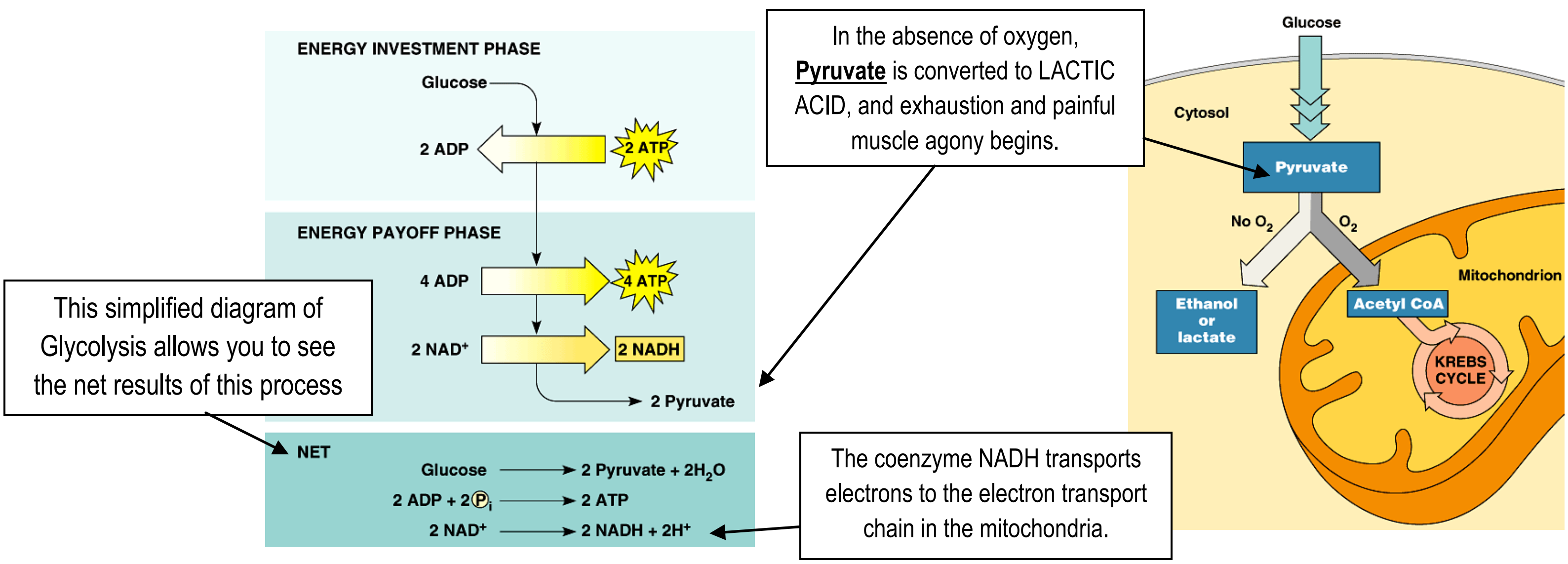
2. Anaerobic Glycolytic System (Glycolysis / Lactic Acid System)

When? All activities yet takes time to reach max output
Where? Cytoplasm
Peek Production Lasts: ~ 1 – 3 minutes
Substrate: Glucose (6 carbon sugar molecule)
Process: 11 Reactions Total

- 10 reactions: 1 glucose _ 2 Pyruvate molecules
- 1 reaction: 1 Pyruvate _ Acetly CoA *(pyruvate oxidation)*

Overall reaction

- $C_6H_{12}O_6 + 2ADP + 2P_i \rightarrow 2C_3H_6O_3 + 2\ ATP + 2\ H_2O$
- Uses energy from glucose to join Pi to ADP _ ATP
- Also Get 2 NADH molecules (Nicotinamide Adenine Dinucleotide) *(See diagram below)*



Limitations: produces lactic acid when there is insufficient O2

- Lactic Acid = fatigue & pain
- Build up of lactic acid = inability to breakdown glucose
- Can metabolize lactic acid during cool down (aerobic exercise)

Benefits:

- Twice as many ATP as (ATP-PC system)
- Relatively quick rate of ATP production,
- Glucose is readily available in muscle and blood for this process (stored form of glucose is called glycogen)

Replenishment: During exercise and cool down to eliminate lactic acid, food consumption to replenish glucose stores
Where in sports? Middle distance (400 – 800 m), hockey shift

3. The Aerobic Oxidative Systems (Cellular Respiration)

Aaerobic catabolism (in the presence of O_2) of Carbohydrate's, fats & proteins to make ATP

When?

- Always running, takes upwards of a minute to reach full capacity (depends on intensity)
- Major contributor after ~ 90 seconds of exercise.

Where? Mitochondrion

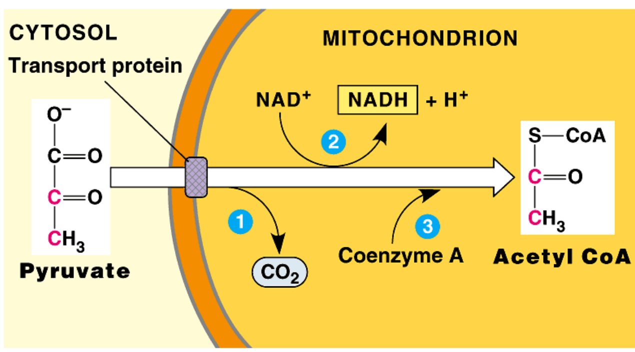
Peek Production Lasts? indefinitely (we stop exercising before the pathways stops or before we run out of substrates)

Substrates: glucose, fats & proteins

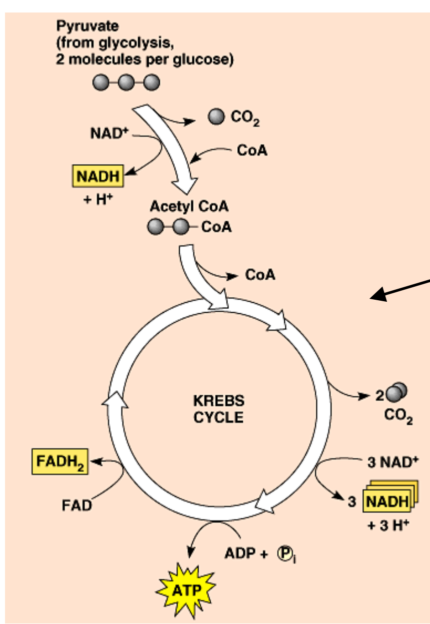
Process:

- **Aerobic Glycolysis** (Cytoplasm)
    - 2 ATP, 2 NADH and 2 Pyruvate

- **Pyruvate Oxidation**
    - 2 Pyruvate ⟶ Acetyl CoA (2 more NADH)

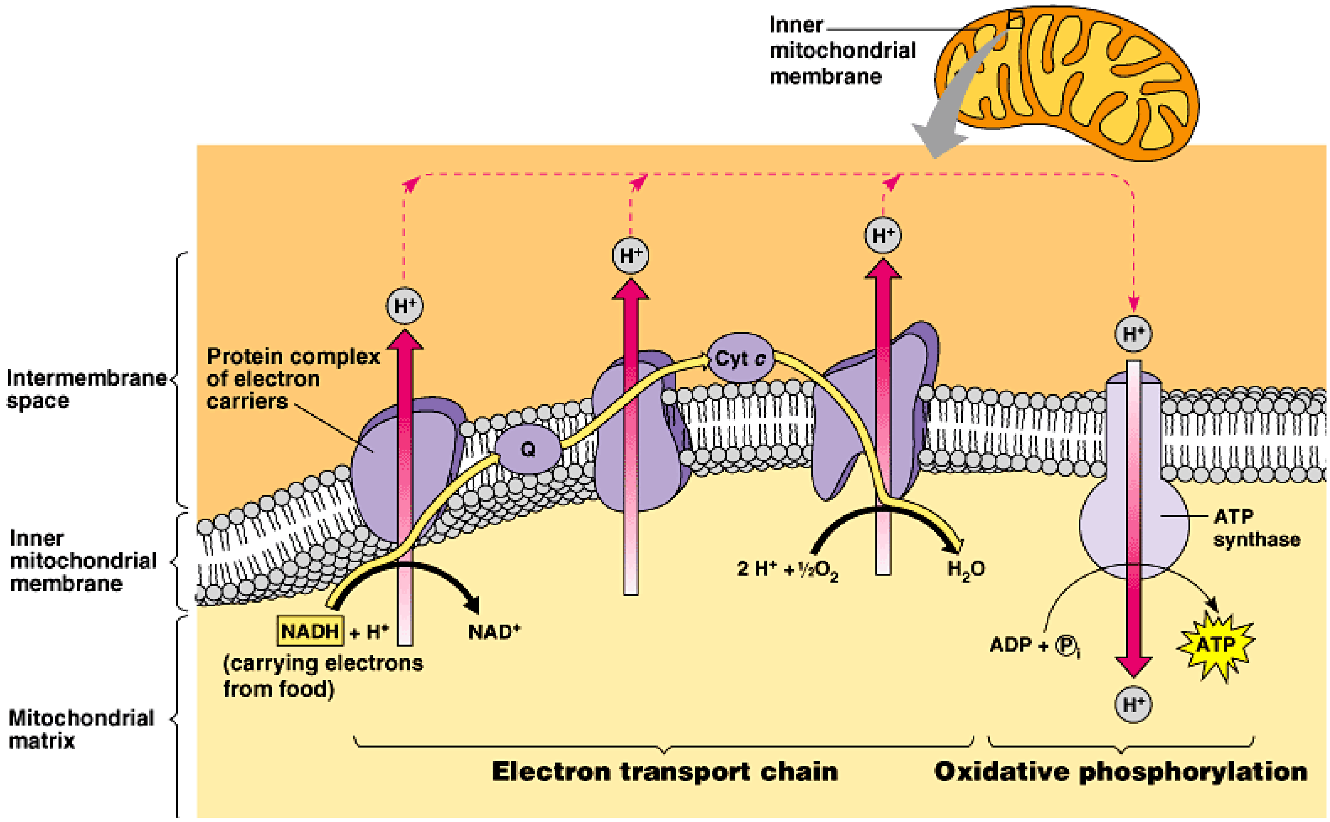


- **Krebs Cycle** (Mitochondrion)
    - 6 NADH & 2 $FADH_2$ + 2 ATP



This cycle (also called Citric acid cycle) happens twice for each glucose molecule. This is because the result of Glycolysis is **2 Pyruvate** molecules)

- **Electron Transport Chain** (in mitochondrion)
  - Converts NADH (3 ATP) and FADH2 (2 ATP)



All together we get the following:

$$C_6H_{12}O_6 + 6O_2 + 38ADP + 38P_i \Longrightarrow 6CO_2 + 38ATP + 6H_2O$$
$$C_6H_{12}O_6 + 6O_2 + 36ADP + 36P_i \Longrightarrow 6CO_2 + 36ATP + 6H_2O$$

Limitations: Takes longer to start i.e. there is a lag period before production of ATP meets demands of activity

Benefits: One glucose = 36 – 38 ATP (18 - 19 X's better than glycolysis)
Replenishment: During recovery & food consumption
Where in sports? Distance running, soccer, rugby, triathlon

NOTE: Cellular respiration also includes:

- Beta Oxidation (breakdown of fats to produce ATP in the presence of O2)
- Oxidative Deamination (breakdown of protein to produce ATP in the presence of O_2)